PMSD/ISB

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN 14 1989

OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: I.D. No. 100-587. Metolachlor registration standard follow-up. Ciba-Geigy submission dated January 27, 1989. MRID Nos. 40980702 to 40980708 and 40766601 and 40766602. DEB #4931.

FROM: Robert S. Quick, Chemist
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and

Toxicology Branch, FHA Support
Health Effects Division (H7509C)

Attached is a registration standard follow-up review prepared by Dynamac Corporation under supervision of Dietary Exposure Branch, HED. This submission was the registrant's response to residue chemistry data requirements.

This Dynamac memo has undergone secondary review in Dietary Exposure Branch and reflects Branch policies.

If you need additional input, please advise us.

Attachment: Metolachlor. Task 4: Registrant's Response to Residue Chemistry Data Requirements.

cc with attachment: R. Quick, Metolachlor R.S. File, R.F., Circ. (7), Metolachlor S.F., ISB/PMSD (Eldredge)

RDI:Br.Sr.Scientist:R.Loranger:6/8/89
H7509C:DEB:CM#2:Rm810G:557-7888:RSQ:6/8/89:mb:6/12/89

DYNAMAC
CORPORATION

Final Report

METOLACHLOR
Task 4: Registrant's Response to Residue Chemistry Data Requirements

Contract No. 68-D8-0080

May 4, 1989

Submitted to:
Environmental Protection Agency
Arlington, VA 22202

Submitted by:
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METOLACHLOR

REGISTRANT'S RESPONSE TO RESIDUE CHEMISTRY DATA REQUIREMENTS

Task - 4

BACKGROUND

The Residue Chemistry Chapter dated 1/16/87 for the Metolachlor Final Registration Standard and Tolerance Reassessment (FRSTR) identified outstanding data gaps for plant metabolism; storage stability; residue field trials for beans and peas; and processing data for potatoes, soybeans, field corn, cottonseed and peanuts. In response to these data requirements, Ciba-Geigy Corporation has submitted seven volumes of data (MRIDs 40980702, 40980703, 40980704, 40980705, 40980706, 40980707, and 40980708) which are reviewed here for their adequacy in fulfilling the outstanding data gaps regarding metabolism in plants, extraction efficiency of the residue method, storage stability and magnitude of the residue in potatoes, beans, peas and processing fractions of potatoes, soybeans, corn, cottonseed and peanuts.

Outstanding Deficiencies Remaining to be Resolved

Potato Metabolism

Method Extraction Efficiency

Food/Feed Additive Tolerance Proposals for Potato Products and Peanut Meal

Chromatograms for Soybean Hulls

Residue Data for Soybean Grain Dust

CONCLUSIONS

1(a). The nature of the residue in potatoes is not adequately understood. The identity of metolachlor metabolites in potato tubers must be confirmed by a second chromatographic system or by some other suitable method such as mass spectrometry.

1(b). Representative samples from [^{14}C]metolachlormetabolism studies must also be analyzed by the residue analytical methods developed for data collection and tolerance enforcement to ascertain that the methods are capable of adequately recovering and quantifying all residues of concern.

2(a). The metabolite CGA-37913 is stable in or on corn grain and forage, peanut nutmeat, potato tubers, beef liver, milk, and eggs stored at -15 $\pm$ 5 C for up to 394 days; however, residues in corn

oil are unstable under lengthy storage, declining to ca. 54-58% of the fortification level by 193 days of storage, and to <10-50% by 377 days of storage. Residues in beef muscle are also unstable, declining to <10-36% of the fortification level by 109 days of storage.

2(b). The metabolite CGA-49751 is stable in or on corn grain, oil, and forage, peanut nutmeat, potato tubers, beef muscle, liver, milk, and eggs stored at -15 ± 5 C for up to 394 days.

3. Data requirements for field trials data for the granular formulation of metolachlor on beans and peas (dried and succulent) should be waived. These uses are to be removed from the Dual 25G label by the registrant.

4(a). Residues of metolachlor concentrate in some of the processed products of potatoes. Feed additive tolerances should be established on dry potato peel, granules, wet peel, and processed potato waste.

4(b). No detectable residues of CGA-37913 and CGA-49751 occur in corn grain, crude oil, refined oil, or milled products as a result of preemergence applications of metolachlor up to 2.5x the maximum registered use rate.

4(c). Data have not been submitted concerning the potential for metolachlor residues to concentrate in corn grain dust; however, this requirement is waived due to the absence of measurable weathered residues in or on corn grain following applications of metolachlor up to 2.5x the maximum registered use rate.

4(d). Chromatograms from the residue analysis for metolachlor in or on hulls processed from soybean seeds treated at 1, 3, and 5x the maximum registered use rate are required to complete the review of data submitted in MRID 40980706. Upon receipt of these chromatograms the potential for concentration of residues in soybean hulls will be evaluated.

4(e). Data are required depicting the potential for concentration of metolachlor residues of concern in soybean grain dust.

4(f). There were no measurable residues of CGA-37913 and CGA-49751 in or on cotton seeds or their processed products as a result of application of metolachlor up to 5x the maximum registered use rate.

4(g). Metolachlor residues concentrate 2.5-3 times in presscake/meal processed from peanut nutmeat; therefore, a feed additive tolerance should be established for peanut meal.

RECOMMENDATIONS

Ciba-Geigy Corporation should be notified of the following:

1. The metabolism data submitted for potatoes do not fulfill the outstanding data gap specified on page 1. The registrant should be encouraged to discuss protocols for additional studies with the Dietary Exposure Branch before initiating any experiments.

2. They are required to propose food/feed additive tolerances for metolachlor residues of concern as follows:

Dry potato peel	4 ppm
Wet potato peel	0.5 ppm
Granules	0.5 ppm
Processed potato waste	4 ppm
Peanut meal	2 ppm

3. A decision regarding the need for a food additive tolerance for metolachlor residues in soybean hulls cannot be made without supporting chromatograms (ABR-88169; MRID 40980706) depicting residues of metolachlor in or on hulls processed from soybean seeds treated at 1, 3, and 5x.

4. Data are required depicting the potential for concentration of metolachlor residues of concern in soybean grain dust.

DETAILED CONSIDERATIONS

Qualitative Nature of the Residue in Plants

The Metolachlor Guidance Document dated January, 1987 concluded that the metabolism of metolachlor is adequately understood in corn and soybeans but required additional data reflecting the uptake, distribution, and metabolism of phenyl-labeled [^{14}C]-metolachlor in potatoes following foliar applications. In response to the Guidance Document, Ciba-Geigy Corp. has submitted report ABR-88110 (1988; MRID 40766601) pertaining to the metabolism of phenyl-labeled [^{14}C]metolachlorin potato plants following both foliar and preemergence applications in the greenhouse and preemergence applications in the field.

Preemergence applications: Phenyl-labeled [^{14}C]metolachlor(25.6 µCi/mg; 99.2% pure) was applied at ca. 1 lb ai/A (as determined by LSC) immediately after planting potatoes in a 3 x 6 ft field plot. Foliage was harvested 45 (25% mature), 63 (50% mature), and 133 (mature) days posttreatment, and mature tubers 133 days posttreatment. In another test conducted in the greenhouse, potatoes planted in pails were top-dressed with soil which had

been treated with 481 μCi of phenyl-labeled [^{14}C]metolachlor(22.3 μCi/mg; 99.1% pure), equivalent to 3 lb ai/A. Foliage was harvested 27 (25% mature), 59 (50% mature), and 109 (mature) days posttreatment, and mature tubers 109 days posttreatment.

Foliar application: Thirty-one days after planting in greenhouse pails, potato plants received a foliar layby application of 452 μCi of phenyl-labeled [^{14}C]metolachlor(25.2 μCi/mg; 99.4% pure), equivalent to 2.5 lb ai/A. The soil surface was covered by kraft paper to prevent contamination. Foliage and roots were harvested 0, 7, 14, 21, and 74 days posttreatment; mature tubers were also harvested 74 days posttreatment.

All samples were shipped on dry ice and stored at -15 C, for an unspecified period of time until analysis. Radioactivity in plant and soil samples was quantified by liquid scintillation counting (LSC) following combustion. Plant samples containing radioactivity >0.03 ppm were subjected to a biphasic extraction procedure (Bligh-Dyer), which separated radioactive residues into organosoluble, aqueous soluble, and unextractable fractions. In addition, bulk extraction of the field grown and greenhouse foliar treated potatoes using a methanol/water (80/20; v/v) solvent mixture was conducted. Methanol was evaporated from the initial extract and the aqueous concentrate was partitioned sequentially with hexane and chloroform. Radioactivity in each fraction was determined by direct LSC.

The hexane and chloroform fractions were analyzed by TLC. HPLC analysis was also conducted on the organic fractions from the field grown potatoes. The aqueous fractions were split, one part was analyzed by TLC, and the other part separated into two clusters by anion exchange chromatography using a Bio-Rex-5 column (field grown and greenhouse foliar). Cluster 1 contained neutral or basic metabolites, and cluster 2 acidic metabolites. Following further purification of cluster 1 on a Bond Elute C18 adsorption column and cluster 2 by cation exchange on Aminex A-4, metabolites were identified by TLC.

Identification of metabolites present in potato samples were based solely on comparison of TLC R_f values or HPLC retention times to those of standard compounds (CGA-110186 and CGA-118243) or to metabolites previously identified in corn.

The total radioactive residue (TRR; expressed as ppm metolachlor equivalents) in foliage from field-treated potatoes increased from 0.08 ppm at 45 days to 0.29 ppm at 133 days (maturity) following preemergence field application. At maturity, residues in the tuber were 0.04 ppm. Of the TRR present in mature tubers, 16.3% was organosoluble, 65.4% was water-soluble, and 15.9% was unextractable; distribution of ^{14}C-activityamong the fractions from mature foliage was similar.

The TRR in potato foliage from greenhouse-grown plants was 1.51 ppm at 27 days, 1.45 ppm at 59 days, and 2.7 ppm at 109 days (maturity) following preemergence application. At maturity, residues in the tuber were 0.36 ppm. Of the TRR present in mature tubers and foliage, respectively, 4.0% and 4.3% was organosoluble, 60.5% and 74.0% was water-soluble, and 27.1% and 12.9% was unextractable.

The TRR in or on foliage immediately after foliar application in the greenhouse was 26 ppm; residues decreased steadily to 4 ppm at maturity (74 days posttreatment). At maturity, residues in samples of tuber were 0.02 ppm. Residues in or on roots were 0.02-0.28 ppm over the 74 day period with the highest concentration occurring at 14 days posttreatment. The ^{14}C-activityin organosoluble fractions of potato foliage decreased from 47% immediately after treatment to 5.4% at maturity. The ^{14}C-activity in water-soluble fractions steadily increased from 53% immediately after treatment to 83% at maturity. Nonextractable radioactivity accounted for 2.9% of the TRR immediately after treatment, and increased to 14.5% at maturity.

HPLC separation of the organosoluble fractions from mature field-grown tubers isolated five components. Three chloroform-soluble components were identified by co-elution with known standards as CGA-37735 (III) at 6.5%, CGA-42444 (IV) at 7%, and CGA-37913 (II) at 1.7% of the total ^{14}C-activity. Two hexane-soluble components which accounted for 1.1% of the total ^{14}C-activityremained unidentified. Additional characterization of these components was not conducted because of the low level of radioactivity and the small quantities of materials in these fractions.

One-dimensional TLC analysis (using an undescribed solvent system) of the water-soluble fraction from preemergence treated field potatoes separated 13 zones each from the tuber and the foliage (Table 1).

Table 1. Partial characterization of aqueous soluble [^{14}C]-metolachlor metabolites in mature foliage and tubers following preemergence application in the field.

TLC Zones	% of total ^{14}C		Identity[1]
	Foliage	Tuber	
Identified			
II	6.5	13.6	VIII
III	10.7	1.6	IX
IV	6.2	4.0	VII
VI	6.2	1.2	VI
VII	8.4	4.3	V
Total	38.0	24.7	
Unidentified			
Origin	3.0	18.7	unknown
I	3.6	9.0	unknown
IVa	4.4	1.3	unknown
V	4.4	4.2	unknown
VIa	2.7	1.0	unknown
VIII	2.6	3.2	unknown
IX	0.7	3.3	unknown
X	1.1	<0.1	unknown
XI	<0.1	<0.1	unknown
Total	22.5	40.7	

[1] Roman numerals designate metabolites listed in Table 2; compounds VI and V were identified by cochromatography with synthesized standards, and the identity of compounds VII, VIII, and IX is inferred by comparison to chromatographic patterns obtained by TLC of water-soluble fractions from corn stalks.

The cluster 1 (acidic) and cluster 2 (neutral and basic) aqueous soluble metabolites present in field- and greenhouse-treated mature tubers were also subjected to one-dimensional TLC and compared to a similar extract of residues from corn plants. A representative autoradiogram of a TLC plate as well as a table depicting the quantitative distribution of radioactivity on the TLC plate have been presented in support of the registrant's claim that water-soluble metabolites in potatoes are identical to those in corn (MRID 40766601). However, we find that the autoradiogram does not provide sufficient resolution to substantiate this claim. Moreover, the tabulated quantitative values claim quantitative separation of radioactive zones that simply do not correspond to the autoradiography of the plate.

TLC of the organic and aqueous extracts from the potato foliage harvested 0 to 74 days after foliar treatment provided a qualitative presentation of the metabolism of metolachlor over time.

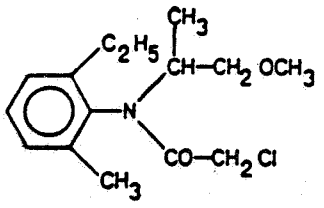
The major radioactive zones found in the 0 day samples of foliage diminished to negligible distinction at 74 days posttreatment. Identical R_f values of major radioactive zones from the various harvest intervals were reported to be unaltered metolachlor (I) in the organic fraction and a conjugate of metolachlor such as a cysteine conjugate in the aqueous fraction; identification of these moieties was not supported by cochromatography with known standards.

In summary, potato plants exhibit foliar and root uptake of [^{14}C]metolachlorbut translocation from foliage to tubers is limited. The parent compound is extensively metabolized both in the potato tuber and foliage. At maturity, 4.0-16.3% of TRR present in mature field- and greenhouse-grown tubers was organosoluble, 60.5-65.4% was water-soluble, and 15.9-27.1% was unextractable. The registrant concludes that metabolism of metolachlor in potato plants is qualitatively identical to that previously found acceptably described for corn. However, the raw data submitted in support of this contention are limited and appear, at least partially, to conflict with this conclusion. Metabolites in potato tubers and foliage were identified solely on the basis of migration in one TLC solvent system or retention time on HPLC. These comparisons to corn metabolites must include, at a minimum, cochromatography with known metabolites in at least two systems. A total of 13 aqueous soluble metabolites and five organic soluble metabolites were resolved from potato foliage and tuber on TLC or HPLC. Eight of these metabolites (40% of the total radioactivity in the tuber) were identified (see Table 1 and Table 2).

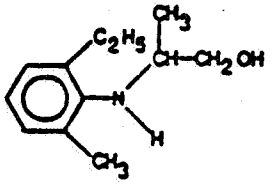
The qualitative nature of the residue in potatoes is not adequately described because no confirmation of identities of the potato metabolites (i.e. identity with corn metabolites) was provided. Representative samples must also be analyzed by enforcement methods to ascertain that these methods are capable of determining all metabolites of concern.

Table 2. Metolachlor and its metabolites in potato foliage and tubers.

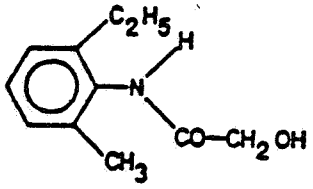
Code	Chemical name Structure	Identification method Common name
I	2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide	TLC **Metolachlor**



II	2-[(2-ethyl-6-methylphenyl)amino]-1-propanol	HPLC (nonpolar peak E) **CGA-37913**

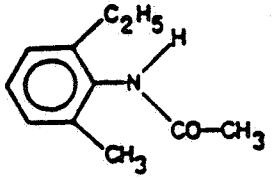
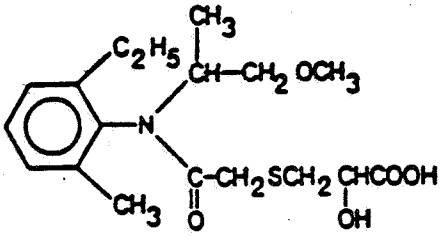
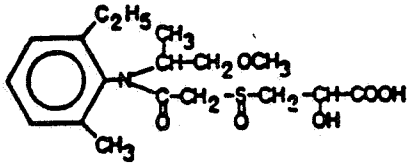


III	N-(2-ethyl-6-methylphenyl)-2-hydroxyacetamide	HPLC (nonpolar peak C) **CGA-37735**



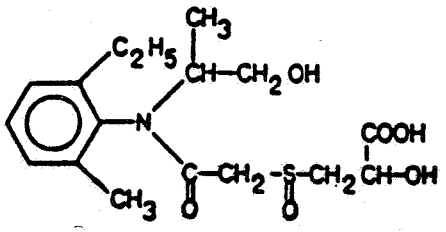
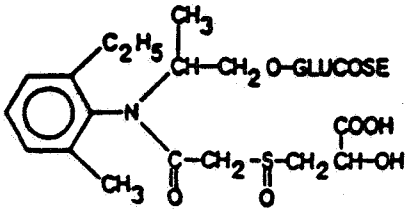
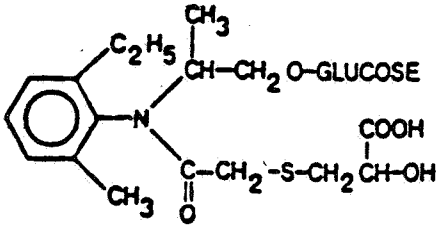
(Continued)

Table 2. Metolachlor and its metabolites (continued).

Code	Chemical name Structure	Substrate	MRID Common name
IV	N-(2-ethyl-6-methylphenyl)acetamide	HPLC (nonpolar peak B)	CGA-42444
			
V	S-conjugate with lactic acid of N-(2-ethyl-6-methyl-phenyl)-2-(mercapto)-N-(2-methoxy-1-methylethyl)acetamide	TLC (zone VII)	CGA-110186
			
VI		TLC (zone VI)	CGA-118243
			

(Continued)

Table 2. Metolachlor and its metabolites (continued).

Code	Chemical name Structure	Substrate	MRID Common name
VII		TLC (zone IV)	(Desmethyl deriv. of CGA-118243)
VIII		TLC (zone II)	Sugar conj. of CGA-118243
IX		TLC (zone III)	Sugar conj. of CGA-110186

Qualitative Nature of the Residue in Animals

The Metolachlor Final Registration Standard and Tolerance Reassessment (FRSTR) dated 1/16/87 concluded that the qualitative nature of the residue in animals is adequately understood.

Residue Analytical Methods

All samples were prepared for analysis according to FDA Pesticide Analytical Manual Vol. I, Section 141. Ciba-Geigy method AG-338 was used to generate the submitted residue and storage stability data (MRIDs: 40980702, 40980703, 40980704, 40980705, 40980706, 40980707, 40980709). This method was discussed in the Metolachlor Final Registration Standard and Tolerance Reassessment (FRSTR) dated January 16, 1987, and it is adequate for determining the combined residues of metolachlor and its metabolites, determined as the derivatives, CGA-37913 and CGA-49751. Method AG-338 is a variation of Ciba-Geigy method AG-286, which is the method for regulatory enforcement listed as Method I in PAM, Vol. II, having successfully undergone a method trial (R. Watts memorandum; July 28 & 29, 1976). Method AG-338 was modified in these studies by the use of differing columns and detectors. All residue data were supported with recovery data from samples fortified with known amounts of CGA-37913 and CGA-49751. Refer to individual sections for the specific columns and detectors used, and for recovery data.

In brief, metolachlor and its metabolites (free plus bound) are hydrolyzed to CGA-37913 and CGA-49751 by refluxing in 6N HCl, which are then determined individually by gas liquid chromatography (GLC).

CGA-49751 residues are partitioned into dichloromethane, washed with 5% sodium carbonate, then chromatographed on 16% moisture silica gel column. Residues of CGA-49751 are then converted to the chloroethyl derivative which is partitioned into hexane and cleaned up on a 16% moisture silica gel column. Quantification is by GLC using a nitrogen-phosphorus detector. Residues of CGA-37913 are partitioned into hexane following the addition of sodium hydroxide solution. The residues are cleaned up by the use of successive chromatographic columns - first alumina (18% moisture) and then silica gel. Quantification is by GLC using nitrogen-phosphorous detection.

Storage Stability Data

Ciba Geigy (1989; MRIDs 40980702 and 40980703) submitted two studies concerning the stability of CGA-37913 and CGA-49751 in plant and animal substrates during frozen storage. Five 10-gram samples each of beef muscle, beef liver, milk, eggs, potatoes, and corn oil obtained from commercial sources, and untreated samples corn forage, corn grain, and peanut nutmeats obtained from the registrant's freezer facility were homogenized and weighed into separate glass jars. Two samples each per substrate were fortified with 0.5 ppm each of CGA-37913 and CGA-49751 prior to freezer storage at -15 ± 5 C. Three unfortified samples were frozen: one as an untreated control, and the two others for fortification and analysis at sampling to indicate procedural recoveries. Refer to Table 3 for the storage stability of 0.5 ppm CGA-37913 and CGA-4971 fortified corn grain, oil, and forage, peanut nutmeats, and potato tubers samples. Results were corrected for control values and procedural recoveries <100%.

Table 3. Storage stability of CGA-37913 and CGA-49751 (in metolachlor equivalents) in corn grain, oil, and forage, peanut nutmeats, potatoes, beef muscle and liver, milk, and eggs samples fortified at 0.5 ppm prior to freezer storage at -15 ± 5 C.

Substrate	Storage Interval (days)	Percent Recovery of 0.5 ppm fortification[1] CGA-37913	CGA-49751
Corn grain	0	70, 82	96, 108
	31-32	72, 82	94, 96
	96	74, 100	98, 100
	188	72, 72	84, 118
	371	104, 104	98, 100
Corn oil	0	94, 106	90, 116
	43	102, 106	78, 118
	102	76, 102	108, 116
	193	54, 58	144, 144
	377	50, <10	90, 98
Corn forage	0	84, 106	116, 134
	32	94, 104	106, 108
	96	122, 122	90, 102
	186	70, 162	60, 66
	396	98, 122	98, 110
Peanut nutmeat	0	90, 98	88, 116
	31-34	82, 90	90, 100

(Continued).

Table 3. (Continued).

Substrate	Storage Interval (days)	Percent Recovery of 0.5 ppm fortification[1] CGA-37913	CGA-49751
	104	98, 102	106, 110
	215	62, 66	98, 106
	374	70, 98	74, 90
Potato tubers	0	106, 116	94, 96
	34	66, 70	76, 84
	104	82, 94	118, 130
	220	62, 72	102, 106
	374	98, 106	76, 76
Beef muscle	0	114, 106	94, 94
	52	114, 122	90, 96
	109	18, 16, 36, <10	96, 82
	222-235	16, 18, 18, 32	96, 68
	376	16, 32	112, 90
Beef liver	0	96, 78	96, 94
	52	108, 92	102, 102
	110	112, 120	80, 84
	227	88, 72	102, 110
	376	90, 54	110, 66
Dairy milk	0	96, 88	80, 120
	34-54	92, 68	82, 90
	112	102, 104	92, 120
	229	84, 58	90, 94
	367	100, 110	120, 104
Poultry egg	0	112, 122	134, 110
	54	84, 104	98, 92
	116	122, 112	88, 116
	231	92, 96	74, 78
	377	102, 172	72, 98

[1]Duplicate analysis.

These data indicate that residues of metolachlor, determined as the derivatives CGA-37913 and CGA-49751, are relatively stable in corn grain, corn forage, peanut nutmeats, potatoes, beef liver, milk, and eggs stored at -15 ± 5 C for ca. 1 year (371-394 days). Residues of CGA-37913 were stable in corn oil for 102 days and then decreased to ca. 54-58% of the initial fortification level after 193 days and to <10-50% after 377 days of storage. Residues of CGA-49751 remained stable in corn oil for the 377-day storage interval. Residues of CGA-37913 were stable in beef

muscle for 52 days and then decreased to <10-36% of the initial fortification level after 109 days of storage; no additional decline was observed through the 376 days of storage. Residues of CGA-49751 remained stable in beef muscle for the 376-day storage interval.

Residues of CGA-37913 and CGA-49751 were nondetectable (<0.05 or <0.25 ppm and <0.05 or <0.15 ppm, respectively) metolachlor-equivalents in or on all untreated control samples with the exception of one 0-day corn forage sample which yielded CGA-49751 residues of 0.21 ppm. Modification of Ciba-Geigy method AG-338 for these analyses included the use of a megabore capillary column and nitrogen/phosphorous detection. The limits of detection are 0.03 ppm for CGA-37913, and 0.05 ppm for CGA-49751. Refer to Table 4 for the procedural recovery values from duplicate analyses of five freshly fortified samples each of corn grain, oil, and forage, peanut nutmeats, potatoes, beef muscle and liver, milk, and eggs.

Table 4. Recoveries of CGA-37913 and CGA-49751 (in metolachlor equivalents) from five freshly fortified samples each of corn grain, oil, and forage, peanut nutmeats, potatoes, beef muscle and liver, milk, and eggs.

Substrate	CGA-37913		CGA-49751	
	Fortification (ppm)	Recovery (%)	Fortification (ppm)	Recovery (%)
Corn forage	0.5	67-122	0.5	60-133
Corn grain	0.5	64-122	0.5	68-113
Corn oil	0.5	84-142	0.5	72-119
Peanut nutmeat	0.5	67-103	0.5	73-110
Potato tuber	0.5	62-103	0.5	76-109
Beef muscle	0.5	51-118	0.5	77-109
Beef liver	0.5	59-115	0.5	65-142
Dairy milk	0.5	62-107	0.5	68-109
Poultry eggs	0.5	68-146	0.5	62-122

Magnitude of the Residue in Plants

Ciba-Geigy Corp. has elected to delete beans and peas (dried and succulent) from their Dual 25G label (EPA Reg. No. 100-587) in response to a request for residue data from crop field trials representing registered uses of granular formulations of metolachlor on these crops. The remainder of the data gaps concerned the magnitude of residues on processed commodities.

It is noted that the registrant reported phytotoxicity at the highest exaggerated use rates for each commodity tested. It is

claimed by the registrant that for purposes of obtaining measurable weathered residues, applications at exaggerated rates higher than those rates already tested would be impractical.

Potatoes

Ciba-Geigy (1989; MRID 40980704) submitted a study concerning residues of metolachlor in processed fractions from potatoes. A preemergence broadcast application followed 79 days later by a layby directed application of metolachlor (DUAL 8E) at 3 + 2.5 lb ai/A (1x the maximum registered use rates), 9 + 7.5 lb ai/A (3x), and 15 + 12.5 lb ai/A (5x) were applied to potatoes in 24 gallons of water per acre using ground equipment. Mature potatoes were harvested 40 days posttreatment, stored for 17 days at 10-21 C and commercially processed into chips, wet peel, dry peel, flakes, wet peel (abrasive), sliced and peeled tubers, and wash water. The processed fractions were immediately frozen, shipped on dry ice, and stored at -18 to -21 C. Prepared samples were placed in polyethylene bags or bottles and shipped frozen to ENCAS Analytical Laboratories located in Winston-Salem, NC. The samples were stored at -5 to -15 C prior to analysis. From processing to residue analysis, samples may have been stored for 397-470 days at -5 to -20 C. Refer to Table 5 for residues and concentration factors of CGA-37913 and CGA-49751 (in metolachlor equivalents) in raw and processed potatoes. Residues were corrected for procedural recoveries <100%.

Table 5. Residues and concentration factors of CGA-37913 and CGA-49751 (in metolachlor equivalents) in processed fractions produced from potatoes harvested 40 days posttreatment with metolachlor at 1, 3, and 5x the maximum registered use rate.

Fraction	Metolachlor Rate (x)	Residues in metolachlor equivalents (ppm) CGA-37913	CGA-49751	Combined[1]	Concentration Factor[1]
Tuber	1	<0.03	<0.05	<0.08	-
	3	<0.03, <0.03	0.06,<0.05	0.06	-
	5	<0.03, <0.03	<0.05,<0.05,0.04	0.04	-
Wet Peel	1	<0.03	<0.05	<0.08	-
	3	0.05	<0.05	0.05	0.8
	5	0.08	<0.05	0.08	2
Dry Peel	1	0.05, 0.05	<0.05, <0.05	0.05	-
	3	0.07, 0.14	0.13, 0.08	0.27	4.5
	5	0.17, 0.51	0.18, 0.17	0.69	17.25
Wet Peel (abrasive)	1	<0.03	<0.05	<0.08	-
	3	0.03	<0.05	0.03	0.5
	5	0.10	<0.05	0.10	2.5
Flakes	1, 3	<0.03	<0.05	<0.08	-
	5	<0.03	0.06 (0.08)	0.08	2
Chip	1, 3, 5	<0.03	<0.05	<0.08	-

[1] Only measurable residues were used in calculating combined residues and concentration factors.

Modification of Ciba-Geigy method AG-338 for these analyses included the use of a DB-Wax Megabore (CGA-37913) and a DB-5 or DB-17 capillary column (CGA-49751). The limits of detection are 0.03 ppm for CGA-37913, and 0.05 ppm for CGA-49751. An untreated control sample, and the potato fractions processed from that sample bore combined residues of CGA-37913 and CGA-49751 at <0.08 ppm (nondetectable). Refer to Table 6 for the recovery values from fortified samples of potato and processed potato fractions.

Table 6. Recoveries of CGA-37913 and CGA-49751 from fortified samples of potato and its processed fractions.

Fraction	CGA-37913		CGA-49751	
	Fortification (ppm)	Recovery (%)	Fortification (ppm)	Recovery (%)
Tuber	0.03-0.1	93	0.05-0.1	73-86
Chip	0.03	90	0.05	113
Wet Peel	0.1	81	0.1	107
Wet Peel (abrasive)	0.2	104	0.2	74
Dry Peel	0.2	86-100	0.2	64-104
Flakes	0.03	76	0.05	76

The field trial was conducted during 1987 in WA which accounted for 17% of the 1987 U.S. potato production (Agricultural Statistics Board, NASS, USDA Crop Database, Jan. 1988).

We note that residues were only marginally detectable in or on the raw agricultural commodity and processed products other than dry peel, even following applications at 5x the registered maximum registered rate. While these data clearly show residue concentration in several of the processed products of potatoes, the concentration factors calculated therefrom may not be entirely reliable. However, the phytotoxicity of metolachlor probably precludes any meaningful improvement in these residue data. An Agency policy memorandum (C.T. Trichilo, dated February 20, 1987) concerning the use of potato waste as a significant livestock feed item notes the need for data concerning the potential for residue concentration in wet peel and dry peel, chips, and granules and the need for a feed additive tolerance for processed potato waste (defined as wet or dried potato pulp, wet or dry potato peel, or a mixture of these commodities) if residues are shown, as they are here, to concentrate.

We conclude that the submitted processing data are sufficient and indicate the need for establishment of food/feed additive tolerances for metolachlor residues of concern as follows:

Dry potato peel	4	ppm
Wet potato peel	0.5	ppm
Granules	0.5	ppm
Processed potato waste	4	ppm

Corn

Ciba-Geigy (1989; MRID 40980705) submitted a study concerning residues of metolachlor in corn processed fractions (dry and wet milling). A preemergence application of metolachlor at 3 lb ai/A (0.5x the maximum registered use rates), 9 lb ai/A (1.5x), and 15 lb ai/A (2.5x) were applied to corn in 20 gallons of water per acre using ground equipment. Mature corn was harvested 158 days posttreatment, frozen and shipped to the Food Protein Center at Texas A & M for commercial processing by wet milling into the following fractions: broken kernels, small grits, meal, flour, hull, germ, presscake and crude oil expeller, presscake and crude oil solvent extracted, refined oil, soapstock, refined bleached oil, and refined bleached deodorized oil; and by dry milling into the following fractions: broken kernels, steepwater concentrate and distillates, dried germ, hull, gluten, starch, coarse gluten starch, process water, presscake and crude oil expeller, presscake and crude oil solvent extracted, refined oil, and soapstock. Processed fractions were frozen and shipped with dry ice to Ciba-Geigy in Greensboro, NC were they were stored at -18 to -21 C. Samples were prepared, placed in polyethylene bags or bottles, and shipped frozen to EN-CAS Analytical Laboratories located in Winston-Salem, NC. The samples were stored at -5 to -15 C prior to analysis. Combined residues of CGA-37913 and CGA-49751 were <0.08 ppm (nondetectable including <0.03 ppm CGA-37913 and <0.05 ppm CGA-49751) in whole grains and in the wet and dry milled fractions produced from these whole grain samples. From harvest to residue analysis samples may have been stored for up to 446 days at -5 to -21 C.

Modification of Ciba-Geigy method AG-338 for these analyses included the use of a DB-5 or DB-17 capillary column. The limits of detection are 0.03 ppm for CGA-37913, and 0.05 ppm for CGA-49751. Residues were nondetectable (<0.03 ppm CGA-37913 and <0.05 ppm CGA-49751) in one untreated control sample and each fraction from wet and dry milling of the untreated control sample. Refer to Table 7 for the recovery values from fortified samples of corn grain and its wet and dry milled fractions. Results were corrected for procedural recoveries <100%.

Table 7. Recoveries of CGA-37913 and CGA-49751 from fortified samples of corn grain and its wet and dry milled fractions.

Fraction	CGA-37913		CGA-49751	
	Fortification (ppm)	Recovery (%)	Fortification (ppm)	Recovery (%)
Dry Milling				
grain	0.1	96	0.1	76
small grits	0.2	84	0.2	54
meal	0.03	63	0.05	74
flour	0.1	97	0.1	77
crude oil[1]				
expeller	0.2	97	0.2	85
solvent extracted	0.1	112	0.1	54
refined bleached & deodorized oil	0.1	85	0.1	90
Wet Milling				
whole kernels	0.03	105	0.05	76
starch	0.1	94	0.1	107
crude oil[1]				
expeller	0.2	80	0.2	93
solvent extracted	0.1	83	0.1	106
refined oil[1]	0.2	83	0.1	106

[1] Storage stability studies (1989; MRID 40980702) indicate that residues of CGA-37913 decrease to 25% of the fortification value in corn oil stored frozen for over a year. Samples of corn oil in this submission were stored frozen for an unspecified period of time prior to analysis. If residues were present in the oil it is possible that significant degradation occurred before analysis.

Field trials were conducted during 1987 in IA, which accounted for 18% of the 1987 U.S. corn grain production (Agricultural Statistics Board, NASS, USDA Crop Database, Jan. 1988).

Wet and dry milled fractions were processed from corn grain which did not bear measurable weathered residues following treatment with metolachlor at 2.5x the maximum registered use rate. Since residue data from processing studies are conditionally required on RACs which contain no detectable residues (refer to a DEB memorandum by C.T. Trichilo, dated November 17, 1988), we conclude that the submitted data from processing studies using corn grain treated at 2.5x the maximum registered use rate are adequate to determine that residues of metolachlor will not concentrate in corn meal and grits, corn starch, or in grain dust. Theoretical concentration factors (determined by information from J. Martin, W. Leonard, and D. Stamp in the Principles of Field Crop Production, 3rd ed.) for processed fractions of corn are

1.6x for starch (wet milled) and 1.9x for small grits and meal (both dry milled). Although the available data do not reflect exaggerated rates equal to or greater than the theoretical concentration factors for flour (14x) and oil (35x), the registrant has indicated that it is not practical to apply higher rates of metolachlor on corn as a means of obtaining measurable residues on the RAC because of phytotoxicity. Moreover, plant metabolism studies show that metolachlor is metabolized by corn to aqueous soluble metabolites, which would not be expected to concentrate in the oil fraction. For these reasons we find the available data sufficient to conclude that residues will not concentrate in crude oil, refined oil, or milled products of corn.

Soybeans

Ciba-Geigy (1989; MRID 40980706) submitted a study concerning residues of metolachlor in or on soybean processed fractions. Metolachlor was applied preemergence to soybeans in 20 gallons of water per acre at 4 lb ai/A (1x the maximum registered use rates), 12 lb ai/A (3x), and 20 lb ai/A (5x) using ground equipment. Mature soybean seeds were harvested 134 days posttreatment, frozen, and shipped to the Food Protein Center at Texas A & M for processing into the following fractions: hulls, meal, crude oil, refined oil, refined bleached hydrogenated oil, refined bleached hydrogenated deodorized oil, and soapstock. The processing fractions were frozen and shipped on dry ice to Ciba-Geigy in Greensboro, NC where they were stored at -18 to -21 C. Prepared samples were placed in polyethylene bags or bottles, and stored frozen until analysis. Refer to Table 8 for details of the residues and concentration factors of CGA-37913 and CGA-49751 (in metolachlor equivalents) in soybean seeds and processed fractions produced from seeds. Results were corrected for procedural recoveries <100%. The storage interval from processing to residue analysis samples may have been from 327 to 448 days at -18 to -21 C.

Modification of Ciba-Geigy method AG-338 for these analyses included the use of a Megabore or a capillary column. The limits of detection are 0.03 ppm for CGA-37913, and 0.05 ppm for CGA-49751. Two untreated control samples and each fraction processed from the untreated controls bore nondetectable residues (<0.08 ppm metolachlor equivalents including <0.03 ppm CGA-37913 and <0.05 ppm CGA-49751). Refer to Table 9 for the recovery values from fortified samples of soybean and its processed fractions. We note that recovery values for CGA-49751 in dry beans, meal, and soapstock are poor.

Table 8. Residues and concentration factors of CGA-37913 and CGA-49751 (in metolachlor equivalents) in soybean seeds and processed fractions produced from seeds harvested 134 days posttreatment with metolachlor at the 1, 3, and 5x the maximum registered rate.

Fraction	Rate (x)	Residues in metolachlor equivalents (ppm) CGA-37913	CGA-49751	Combined	Conc. Factor
dry bean	1	0.04	<0.05	0.04	-
	3	0.06	<0.05	0.06	-
	5	0.09	<0.05	0.09	-
hulls	1	0.05	<0.05	0.05	1.25
	3	0.10	<0.05	0.10	1.7
	5	0.12	<0.05	0.12	1.3
meal	1	0.04	<0.05	0.04	-
	3	0.03	<0.05	0.03	-
	5	0.05	<0.05	0.05	-
crude oil	1,3,5	<0.03	<0.05	<0.08	-
refined oil	1,3,5	<0.03	<0.05	<0.08	-
soapstock	1,3,5	<0.03	<0.05	<0.08	-

Table 9. Recoveries of CGA-37913 and CGA-49751 from fortified samples of soybean and its processed fractions.

Fraction	CGA-37913 Fortification (ppm)	CGA-37913 Recovery (%)	CGA-49751 Fortification (ppm)	CGA-49751 Recovery (%)
dry beans	0.03	96-101	0.05	53-55
hulls	0.1	83	0.1	69
meal	0.03	93	0.05	57
crude oil	0.1	90	0.1	116
refined oil	0.3	97	0.5	84
refined oil[1]	0.3	66	0.03	63
refined oil[2]	0.2	75	0.2	73
soapstock	0.2	99	0.2	57

[1]Bleached and hydrogenated.
[2]Bleached, hydrogenated, and deodorized.

The field trials were conducted during 1987 in MS which accounted for 3% of the 1987 U.S. soybean production (Agricultural Statistics Board, NASS, USDA Crop Database, Jan. 1988).

The milled fractions were processed from soybean seeds which bore measurable weathered residues of the metabolite CGA-37913; however, residues of CGA-49751 were nondetectable. Chromatograms depicting analysis of the soybean seeds treated at 3x the maximum registered use rate indicate a "true" residue of CGA-49751 although the response is below the limit of reliable quantitation. Residues of metolachlor concentrated up to 1.7x in soybean hulls. The registrant proposed that this apparent concentration was actually due to experimental variation but the raw data for hulls in support of this contention were not provided. We conclude that a decision regarding the need for a food additive tolerance for metolachlor residues in soybean hulls cannot be made without supporting chromatograms depicting residues of metolachlor in or on hulls processed from soybean seeds treated at 1, 3, and 5x.

The Agency memorandum by C. Trichilo dated February 13, 1987, concerning the need for residue data on grain dust discusses that grain dust from small grains, corn, rice, and soybeans is considered as a processing by product and as a feed item. Therefore, data are required depicting the potential for concentration of metolachlor residues of concern on soybean grain dust.

Cottonseed

Ciba-Geigy (1989; MRID 40980707) submitted data concerning residues of metolachlor in or on cotton processed fractions. A single preemergence application of metolachlor was made at 2 lb ai/A (1x the maximum registered use rates), 6 lb ai/A (3x), and 10 lb ai/A (5x) in 25.4 gallons of water per acre using ground equipment. Mature cottonseeds were harvested 157 days post-treatment, frozen, and shipped to the Food Protein Center at Texas A & M for processing into the following fractions: linters, linters motes, delinted seeds, hulls, kernels, meal, crude oil, refined oil, refined bleached oil, refined bleached hydrogenated oil, and refined bleached hydrogenated deodorized oil. Processed fractions were frozen and shipped on dry ice to Ciba-Geigy in Greensboro, NC where they were stored at -18 to -21 C. Following preparation, samples were placed in polyethylene bags or bottles, and stored frozen until analysis. Combined residues of CGA-37913 and CGA-49751 were <0.08 ppm (nondetectable, including CGA-37913 at <0.03 ppm and CGA-49751 at <0.05 ppm) in cottonseeds and in the fractions produced from these samples. From harvest to residue analysis samples may have been stored frozen for up to 425 days.

Modification of Ciba-Geigy method AG-338 for these analyses included the use of a DB-5 or DB-17 capillary column. The limits

of detection are 0.03 ppm for CGA-37913, and 0.05 ppm for CGA-49751. One untreated control, and each fraction processed from that sample bore combined residues of <0.08 ppm (nondetectable, including CGA-37913 at <0.03 ppm and CGA-49751 at <0.05 ppm). Refer to Table 10 for the recovery values from fortified samples of cottonseed and its processed fractions. Residue results were corrected for procedural recoveries <100%.

Table 10. Recoveries of CGA-37913 and CGA-49751 from fortified samples of cottonseed and its processed fractions.

Fraction	CGA-37913		CGA-49751	
	Fortification (ppm)	Recovery (%)	Fortification (ppm)	Recovery (%)
seed	0.01-0.03	87-99	0.05-0.1	76-92
delinted seeds	0.5	81	0.5	74
meal	0.2	95	0.2	79
hulls	0.1	78	0.1	84
crude oil	0.1	107	0.1	111
refined oil	0.03	68	0.05	94
refined oil[1]	0.2	99	0.2	61
refined oil[2]	0.1	72	0.1	72
refined oil[3]	0.1	91	0.1	75
soap stock	0.1	95	0.1	75

[1]Bleached.
[2]Bleached and hydrogenated.
[3]Bleached, hydrogenated, and deodorized.

Field trials were conducted during 1987 in MS which accounted for 12% of the 1987 U.S. cotton production (Agricultural Statistics Board, NASS, USDA Crop Database, Jan. 1988).

Fractions were processed from cottonseeds which did not bear measurable weathered residues following treatment at up to 5x the maximum registered rate. Since residue data from processing studies are conditionally required on RACs which contain no detectable residues (refer to a DEB memorandum by C.T. Trichilo, dated November 17, 1988), we conclude that the submitted data from processing studies using cottonseed treated at 5x the maximum registered use rate are adequate to determine that residues of metolachlor will not concentrate in cotton meal, hulls, and crude and refined cotton oils. Theoretical concentration factors for processed fractions of cottonseeds are 5.8x for oil, 3.7x for hulls, and 2.1x for meal as determined from information in Principles of Field Crop Production, 3rd ed., J. Martin, W. Leonard, and D. Stamp. We also conclude that since soapstock is composed largely of polar components (proteins, carbohydrates, and water), residues would not be expected to occur in this processed product.

Peanuts

Ciba-Geigy (1989; MRID 40980709) submitted residue data concerning metolachlor in or on peanut processed fractions. A preemergence application followed by an early postemergence application of metolachlor 6 days later at 3 + 3 lb ai/A (1x the maximum registered use rates), 9 + 9 lb ai/A (3x), and 15 + 15 lb ai/A (5x) were applied to peanuts in 20 gallons of water per acre using ground equipment. Mature peanuts were harvested 124 days posttreatment and shipped frozen to the Food Protein Center at Texas A & M for processing into the following fractions: nutmeat, hulls, crude oil (expeller and solvent extracted), refined oil, refined hydrogenated oil, refined hydrogenated deodorized oil, and soapstock. The fractions were frozen, shipped with dry ice to Ciba-Geigy in Greensboro, NC were they were stored at -18 to -21 C. Samples were placed in polyethylene bags or bottles and shipped frozen to EN-CAS Analytical Laboratories located in Winston-Salem, NC. Refer below to Table 11 for residues and concentration factors of CGA-37913 and CGA-49751 (reported in metolachlor equivalents) in peanut nutmeat and its processed fractions. Results were corrected for procedural recoveries <100%. The samples were stored at -5 to -15 C prior to analysis. From harvest to residue analysis samples may have been stored for up to 441 days between -5 to -21 C.

Field trials were conducted during 1987 in GA, which accounted for 44% of the 1987 U.S. peanut production (Agricultural Statistics Board, NASS, USDA Crop Database, Jan. 1988).

Table 11. Residues and concentration factors of CGA-37913 and CGA-49751 (in metolachlor equivalents) in peanut nutmeat and its processed fractions produced from peanuts harvested 124 days posttreatment with metolachlor at the 1, 3, and 5x the maximum use rate (6, 18, and 30 lb ai/A, respectively).

Fraction	Application Rate (x)	Residues in metolachlor equivalents (ppm)			Concentration Factor
		CGA-37913	CGA-49751	Combined	
Raw Nutmeat	1	0.04	<0.05	0.04	-
	3	0.1	0.1	0.2	-
	5	0.16	0.1	0.26	-
Presscake (expeller)	1	0.04	0.08	0.12	3
	3	0.14	0.19	0.33	1.7
	5	0.19	0.28	0.47	1.8
Presscake (solvent extracted)	1	0.04	0.06	0.1	2.5
	3	0.05	0.16	0.21	1.05
	5	0.09	0.2	0.29	1.1
Crude oil					
expeller	1,3,5	<0.03	<0.05	<0.08	0
solvent extracted	1,3,5	<0.03	<0.05	<0.08	0
Refined oil					
Refined	1,3,5	<0.03	<0.05	<0.08	0
Hydrogenated	1,3,5	<0.03	<0.05	<0.08	0
Hydrogenated & Deodorized	1,3,5	<0.03	<0.05	<0.08	0
Soapstock	1,3	<0.03	<0.05	<0.08	0
	5	0.06-0.07	0.05	0.12	0

Modification of Ciba-Geigy method AG-338 for these analyses included the use of a DB-Wax megabore (CGA-37913) and a DB-5 or DB-17 capillary column (CGA-49751). The limits of detection are 0.03 ppm for CGA-37913, and 0.05 ppm for CGA-49751. Combined residues were <0.08 ppm (nondetectable, including CGA-37913 at <0.03 and CGA-49751 at <0.05) in or on one untreated control sample and fractions processed from the control sample. Refer below to Table 12 for the recovery values from fortified samples of peanut nutmeat and its processed fractions.

Table 12. Recoveries of CGA-37913 and CGA-49751 from fortified samples of raw peanut nutmeat and its processed fractions.

Fraction	CGA-37913		CGA-49751	
	Fortification (ppm)	Recovery (%)	Fortification (ppm)	Recovery (%)
Nutmeat	0.03-0.2	70-79	0.05-0.2	69-87
Crude oil				
expeller	0.1	95	0.1	92
solvent	0.03	109	0.05	85
Presscake				
expeller	0.1	79	0.1	62
solvent	0.2	95	0.2	72
Refined oil	0.03	139	0.05	113
Refined oil[1]	0.1	80	0.1	78
Refined oil[2]	0.2	82	0.2	50
Soapstock	0.03	134	0.05	113

[1]Hydrogenated.
[2]Hydrogenated and deodorized.

We conclude that metolachlor residues may concentrate up to 3x in expeller presscake/meal and 2.5x in solvent extracted presscake/meal processed from peanut nutmeats bearing measurable weathered residues. Residues did not concentrate in crude and refined oils. Therefore, a feed additive tolerance of 2 ppm for metolachlor residues of concern in peanut meal is needed; a food additive tolerance for refined oil is not required.

MAGNITUDE OF THE RESIDUE IN MEAT, MILK, POULTRY, AND EGGS

Tolerances of 0.02 ppm have been established for combined residues of metolachlor and its metabolites determined as CGA-37913 and CGA-49751 and expressed as metolachlor equivalents in milk, eggs, meat, fat, and meat byproducts (except kidney and liver) of cattle, goats, hogs, horses, poultry, and sheep. Tolerances of 0.05 and 0.2 ppm have been established for the same residues in liver and kidney, respectively, of cattle, goats, hogs, horses, poultry (except kidney), and sheep [40 CFR 180.368(a)]. Presently, tolerances for residues of metolachlor in the feed items peanut meal and processed potato waste are needed. The effects on the maximum dietary intake of livestock and the adequacy of the available data regarding the magnitude of the residue in animal products will be reconsidered.

MASTER RECORD IDENTIFICATION NUMBERS

[The following MRIDs contain the data submitted by Ciba-Geigy Corporation in response to data gaps identified in the Residue Chemistry Chapter of the Metolachlor Final Registration Standard and Tolerance Reassessment (FRSTR) dated 1/16/87.]

40766601 Simoneaux, B.J. (1988) Uptake and Characterization of Metolachlor and its Metabolites in Field and Greenhouse Grown Potatoes: Study No. ABR-88110. Unpublished study completed on July 25, 1988 and prepared by Ciba-Geigy Corp. 104 p.

40766602 Simoneaux, B.J. (1988) The Uptake and Distribution of 14C-Metolachlor from Soil in Greenhouse Grown Potatoes: Study No. ABR-81023. Unpublished study completed on July 9, 1981 and prepared by Ciba-Geigy Corp. 35 p.

40980702 Cheung M.W. (1989) Residue Stability Study of CGA-37913 and CGA-49751 (Metolachlor Residue Hydrolysates) in Crops and Crop Fractions Under Freezer Storage Conditions (One-year Interim Report): Study No. ABR-88165. Unpublished study completed on January 20, 1989, and prepared by Ciba-Geigy Corp. 69 p.

40980703 Cheung M.W. (1989) Residue Stability Study of CGA-37913 and CGA-49751 (Metolachlor metabolites) in Beef Muscle, Beef Liver, Dairy Milk, and Poultry Eggs Under Freezer Storage Conditions (One-year Interim Report): Study No. ABR-88166. Unpublished study completed on January 19, 1989, and prepared by Ciba-Geigy Corp. 65 p.

40980705 Cheung M.W. (1989) Residue Summary - Metolachlor Corn Processed Fractions (Dry and Wet Milling): Study No. ABR-88168. Unpublished study completed on January 19, 1989, and prepared by Ciba-Geigy Corp. 87 p.

40980706 Cheung M.W. (1989) Residue Summary - Metolachlor Soybean Processed Fractions: Study No. ABR-88169. Unpublished study completed on January 17, 1989, and prepared by Ciba-Geigy Corp. 71 p.

40980707 Cheung M.W. (1989) Residue Summary - Metolachlor Cotton Processed Fractions: Study No. ABR-88170. Unpublished study completed on January 23, 1989, and prepared by Ciba-Geigy Corp. 73 p.